DOCUMENT RESUME

ED 428 277 CE 078 328

AUTHOR Whittington, M. Susie; McCormick, David F.
TITLE Cognitive Level of Academic Challenges Provided to College Students.
PUB DATE 1998-05-28
NOTE 11p.; Paper presented at the Annual Meeting of the American Vocational Education Research Association (New Orleans, LA, December 11, 1998).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academic Achievement; *Agricultural Education; Cognitive Development; *Cognitive Processes; College Students; *Difficulty Level; Educational Research; Higher Education; *Learning Activities; Student Evaluation; Teaching Methods; *Tests; Thinking Skills

ABSTRACT

A study assessed the cognitive level of academic challenges incorporated into courses offered in the College of Agricultural Sciences at the Pennsylvania State University. Eleven faculty members from nine departments provided copies of all academic challenges used in their courses. They were categorized by type: activities, problem sets, written reports, presentations, laboratory tests, quizzes, midterms, and finals. A number corresponding to one of the six levels of Bloom's taxonomy (knowledge, comprehension, application, analysis, synthesis, evaluation) was assigned to each individual task, question, problem, or action. The value of the academic challenge to students' course grade was calculated based on the grade weighting information provided in each course's syllabus. Findings indicated that the mean cognitive distribution for all the courses' academic challenges was fairly even across the six cognitive levels with an emphasis on the higher cognitive levels. On average, 31.4 percent of the student's grade came from work at the lower cognitive levels and 66.6 from work at the higher levels. Individual presentations, quizzes, midterm exams, and final exams tended to provide lower cognitive challenges for students. Generally, students were rewarded more for completing academic challenges written at the higher cognitive levels and less for lower cognitive work. (Contains 12 references) (YLB)

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ED 428 277

COGNITIVE LEVEL OF ACADEMIC CHALLENGES PROVIDED TO COLLEGE STUDENTS

Dr. M. Susie Whittington
Assistant Professor

The Pennsylvania State University
101 Agricultural Administration
University Park, PA 16802

814-865-7521

David F. McCormick
Graduate Assistant

The Pennsylvania State University
413 Agricultural Administration
University Park, PA 16802

814-863-7852
SWhittington@psu.edu

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COGNITIVE LEVEL OF ACADEMIC CHALLENGES

PROVIDED TO COLLEGE STUDENTS

Introduction

One of the goals established by The National Education Goals Panel was that, "The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively and solve problems will increase substantially" (1991, p. 5). To meet this goal, professors must place greater emphasis on developing students' ability to think at higher cognitive levels. Undergraduate instruction should focus not only on providing students the content knowledge of their chosen discipline, but also on facilitating the development of students' critical thinking skills . As stated by Newcomb,

> The need to have students graduate with the demonstrated capacity to think at the higher levels of Bloom's taxonomy is more urgent than ever. The nature of the world we live in demands it. Given the pace of technological change and the unabated explosion of knowledge, it is fruitless to try to focus on teaching facts, for this is guaranteed to be a losing proposition. (1995, p.4)

How students learn (i.e., how they are challenged to learn) is a key component of this process. If undergraduate students are to develop their ability to think at higher levels of cognition, they must be challenged to do so by both professors' in-class instructional techniques, and by the academic challenges (i.e. homework) provided throughout the course. Studies have examined faculty teaching characteristics and instructional methods with respect to critical thinking skills and opportunities provided by professors for students to engage in higher order thinking (Bowman, 1995; Newcomb & Trefz, 1987; Pickford & Newcomb, 1989; Whittington, 1995; Whittington & Newcomb, 1993).

Additional studies have shown that effective use of academic challenges can increase student achievement (Ziegler, 1986) and can contribute to challenging both students' progression through the thought processes and their development of thinking skills (Meyers, 1986; Terenzini, Springer, Pascarella & Nora, 1995). However, there are few studies which have examined the cognitive level of academic challenges or which provide a system for assessing academic challenges (e.g. Newcomb, 1987; Pickford, 1989; Ratcliff, Jones, Guthrie & Oehler, 1991). Because academic challenges represent additional opportunities for learning and the development of thinking skills, it is important that they are included in the search for ways to improve undergraduate education. There is a need for "systematic assessment and analysis of coursework patterns...[which] can be used to launch new, better-informed bases for student advisement, teaching, and learning" (Ratcliff et al., 1991).

Theoretical Frame

One of the most frequently cited and applied systems for categorizing cognitive processes has been the classification system proposed by Bloom et al. in the Taxonomy of Educational Objectives, Handbook I: Cognitive Domain (1956). This taxonomy classifies cognition and associated behaviors into six hierarchical levels based on the type of cognitive processes required to complete an objective or answer a question. The cognitive levels are cumulative in structure; each level integrates and builds upon the cognitive activities of the levels below it, implying a type of sequence, or a hierarchy, to the levels of thinking. The six levels are:

Knowledge - Involves the recall of specific facts and theories, methods and processes. This level emphasizes remembering learned material (Bloom, 1956). Common action terms for this level include: list, define, label, match and designate who, what and when.

Comprehension - Represents the lowest level of understanding. The individual knows the information which is being communicated and can make use of the material without relating it to other information or seeing its fullest implications (Bloom, 1956). Common action terms for the comprehension level include: explain, paraphrase, summarize, rewrite, and give examples.

Application - Focuses on having students apply what has been learned to different situations and learning tasks, requiring students to use information that they know and understand (Bloom, 1956). Common action terms for this level include: compute, demonstrate, use, predict, discover, and solve.

Analysis - Involves breaking down the information or situations and separating them into their component parts, focusing on the relationships of these parts with each other and with the whole structure (Bloom, 1956). Common action terms for the analysis level include: differentiate, discriminate, relate, diagram, and distinguish.

Synthesis - Focuses on the combination of learned elements and parts to form a new whole. This includes working with pieces and elements and arranging them so as to create a new form, pattern or structure of the information (Bloom, 1956). Common action terms for this level include: create, compose, produce, and develop.

Evaluation - Involves making judgments about the value of material and methods for given purposes. Judgments are made based on standards or criteria, either established and provided for the student or those determined by the student (Bloom, 1956). Common action terms for the evaluation level include: justify, compare, contrast, evaluate, and interpret.

The first two levels, knowledge and comprehension are typically referred to as lower order thinking and the four highest levels (application, analysis, synthesis, and evaluation) represent higher order thinking as they involve more complex processing. Although Bloom's taxonomy is

recognized as not being perfect, it has been widely accepted and used by many educators and researchers.

Purpose and Objectives of the Study

The purpose of this study was to cognitively assess the academic challenges that were incorporated into selected courses offered within the College of Agricultural Sciences at the Pennsylvania State University. The following objectives guided the study:

1. To describe the various types of academic challenges and the frequency with which each type was used in College of Agricultural Sciences courses.

2. To determine the cognitive level at which the students were challenged to think for each academic challenge.

3. To examine the cognitive levels of the academic challenges and their value to the students' final grade.

This study was designed to provide educators with a system to collect benchmark information on the academic challenges they were using. It is hoped that this system will contribute to an increase in professors' effectiveness in writing academic challenges which facilitate the development of their students' higher order thinking ability.

Procedure

Eleven faculty members from nine departments/schools within the College of Agricultural Sciences (agricultural economics, agricultural education, agronomy, animal and veterinary science, dairy science, entomology, forestry, horticulture, and plant pathology), participated in this project. Faculty members were initially nominated for participation by their department chairperson who categorized potential participants as "good" teachers. Final participation in the project however, was voluntary. Each participant provided copies of all the academic challenges used in their course. The participating professors were consulted when necessary, to provide background content information and to clarify any questions raised during the analysis.

The collected academic challenges for each course were examined and categorized by type of challenge. The resulting categories were: activities, problem sets, written reports (individual and group), presentations (individual and group), laboratory tests, quizzes, midterms, and finals.

Each individual task, question, problem, or action within all of the academic challenges was analyzed to determine the cognitive challenge it provided to students. A number corresponding to one of the six levels of Bloom's taxonomy (i.e., 1 = Knowledge, 2 = Comprehension, 3 = Application, 4 = Analysis, 5 = Synthesis, and 6 = Evaluation) was assigned. The analysis was based on the highest level that students would be cognitively challenged in order to answer the item.

In addition to the cognitive assessments, the value of the academic challenge to students' course grade was calculated. This was based on the grade weighting information provided in each course's syllabus which detailed the value of all the academic challenges provided to the students' final grades.

The collected data were compiled and entered into a spreadsheet which contained the complete listing of the academic challenges provided in the course and each academic challenges' cognitive distribution. The cognitive distribution was based on the cognitive assessment of the academic challenge. It describes the portion of each cognitive level included in the academic challenge. For example, a problem set may have a cognitive distribution of: 0% knowledge, 7.1% comprehension, 71.4% application, 7.1% analysis, 0% synthesis, and 14.4% evaluation. In other words, 7.1% of this example was written to challenge students at the lower cognitive levels and 92.9% challenged the students at the higher cognitive levels. From this spreadsheet, the courses' mean cognitive distribution for the academic challenges provided was calculated.

A second spreadsheet was used to calculate the grade-weighted cognitive distribution. While similar to the above spreadsheet, this spreadsheet included the value of each academic challenge to the students' final grades. To obtain the grade weighted cognitive distribution, the initial cognitive distribution for each academic challenge was multiplied by its value to the students' final grade.

Several of the courses provided academic challenges which contained individual items with different point values (i.e., one question worth 10% of the academic challenge's grade and another question worth 15%). These values were included in the analysis by re-calculating the cognitive distribution for that academic challenge such that it included the weighted value of each item. Then the weighted cognitive distribution for the course could be calculated as described above.

Results

Types of Academic Challenges Provided

As can be seen in Table 1, there was a wide range of both the total number of academic challenges and the number of different types of academic challenges provided to the students. The total number of academic challenges ranged from a low of 6 to a high of 29 academic challenges. The mean number of academic challenges provided by the 11 professors was 13.2.

Table 1

Academic Challenges Provided By Course

	Course										
AC category	A	B	C	D	E	F	G	H	I	J	K
Activities		1		2			1	7	6	19	3
Problem sets			5				14		1	1	
Written reports, ind		4	4	10	1	1	1		4	4	
Written reports, grp	2					7		1	2	1	
Presentations, ind						4					
Presentations, grp	1			1		1		1			
Quizzes	3				3		2			3	
Laboratory test	1										
Midterm exams	1	1	2	3	2	1	2			1	2
Final exams	1	1	1	1	1	1	1				1
Total # of AC provided	9	7	12	17	7	15	21	9	13	29	6
mean = 13.2											
# of categories used	6	4	4	5	4	6	6	3	4	6	3
mean = 4.6											

The number of different types of challenges provided also varied although not as much. On the low end, two professors utilized 3 different types of challenges. The greatest variety of academic challenges was provided by four professors who utilized 6 different types of challenges. The mean number of different types of academic challenges provided by the professors was 4.6.

Cognitive Distribution

The cognitive analysis by course provided information on where the cognitive emphasis was placed for each of the course's academic challenges (Table 2). The mean cognitive distribution for all of the courses' academic challenges was fairly even across the six cognitive levels with an emphasis on the higher cognitive levels. The examination of all the courses resulted in means of 29.6% written at the lower cognitive levels (with a range of 12.2% to 77.3%) and 70.5% written at the higher cognitive levels (with a range of 22.7% to 87.8%). The mean course cognitive distribution was: 11.5% at the knowledge level, 18.1% comprehension, 19.8% application, 15.8% analysis, 17.7% synthesis and 17.2% evaluation.

Table 2

Cognitive Analysis by Course

		Cognitive distribution						Mean % of students' grade					
Course	n	K	C	Ap	An	S	E	K	C	Ap	An	S	E
A	9	3.0	20.3		40.9	29.6	6.1	9.4	20.1		23.5	28.9	18.5
B	7	5.7	11.4	14.3	22.9	10.4	35.3	4.0	9.3	10.0	16.0	15.5	45.3
C	12	8.3	9.1	47.4	14.3	13.1	7.8	16.6	19.5	30.7	17.0	13.2	3.7
D	17	10.1	18.2	10.0	11.6	28.8	21.4	16.5	22.3	8.3	18.2	17.3	16.6
E	7	50.9	26.4	6.5	0.4	13.7	2.0	42.5	16.4	7.8	1.4	28.1	3.7
F	15		35.3	12.3	3.8	19.8	28.7		24.1	18.9	6.0	21.8	29.8
G	21	5.4	10.6	58.6	5.9	2.5	17.1	11.6	27.9	30.3	10.0	2.7	17.8
H	9	7.6	9.5	11.1	28.3	16.4	27.1		6.1		20.1	47.4	26.7
I	13		12.2	11.5	16.9	27.1	32.2		5.2	9.1	15.8	36.8	33.0
J	29	20.4	18.7	20.5	15.0	18.0	7.4	21.3	15.0	12.2	7.6	16.0	4.0
K	6	14.6	27.0	25.8	13.9	15.0	3.7	21.1	36.7	17.7	12.6	9.0	2.8

	K	C	Ap	An	S	E
Mean %:	11.5	18.1	19.8	15.8	17.7	17.2

	K	C	Ap	An	S	E
Total % of final grade:	13.0	18.4	13.2	13.5	21.5	18.4

The overall grade-weighted cognitive distribution shifted the cognitive distribution to: 13% knowledge, 18.4% comprehension, 13.2% application, 13.5% analysis, 21.5% synthesis and 18.4% evaluation. The result was that on average, 31.4% of the students grade came from work at the lower cognitive levels and 66.6% came from work at the higher cognitive levels.

Several courses rewarded the students more for the portion of academic challenges written at the higher cognitive levels. For example, the academic challenges provided in Course H emphasized the higher cognitive levels (a mean of 82.9% written at the higher cognitive levels) and the course's grading structure was set such that over 93.9% of the students' grades came from the work at the higher cognitive levels. Similar shifts were observed in Courses B, E, F, I and J. Conversely, in Courses A, C, D, G and K the opposite occurred, where the lower cognitive levels were worth more than their initial portion of the cognitive distribution. For example, 16% of the academic challenges in Course G was written at the lower cognitive levels, but that 16% was worth 39.5% of the students' final grades. Much of the shift observed in Course G was due to the weight of the quizzes, midterms and the final exam which all emphasized the lower cognitive levels but were worth 80% of the students' final grades.

The analysis by type of academic challenge also revealed several differences in the cognitive distributions (Table 3). On average, the individual presentations, quizzes, midterm exams, and final exams tended to provide lower cognitive challenges for students. These academic challenges were written with means of 87.5%, 69.5%, 65.9% and 52.6%, respectively, at the lower cognitive levels. This emphasis on the lower cognitive levels of knowledge and comprehension is similar to the findings of Newcomb and Trefz (1987). However, within each of

these categories, there are examples of challenges that were written to emphasize the higher cognitive levels.

The other academic challenge categories (activities, problem sets, individual and group written reports, group presentations, and laboratory tests) tended to be written to emphasize the higher cognitive levels. Problem sets placed the greatest emphasis on the higher cognitive levels (a mean of 97.2%). The activities had some emphasis on the lower cognitive levels (a mean of 27.8%) but were still written to emphasize the higher cognitive levels (a mean of 70.2%). Based on the cognitive analysis, it appears that these non-exam types of academic challenges, by their nature, are more conducive to challenging students at the higher cognitive levels of application, analysis, synthesis and evaluation.

Table 3

Academic Challenge Cognitive Analysis

		Cognitive distribution						Mean % of students' grade per AC						
Academic challenge	**n**	**K**	**C**	**Ap**	**An**	**S**	**E**	**K**	**C**	**Ap**	**An**	**S**	**E**	**% Grade**
Activities	39	12.4	17.5	24.7	21.4	7.8	16.3	0.3	0.5	0.9	0.8	0.5	0.6	3.5
Problem sets	21	1.2	1.6	81.4	2.3		13.5		0.1	1.1			0.1	1.3
Written reports, ind	29	0.5	5.1	9.8	17.2	44.0	23.3		0.1	0.8	1.3	2.9	1.9	7.0
Written reports, grp	13		11.5	3.8	7.3	40.4	36.9		0.5	0.3	1.0	3.1	2.1	7.0
Presentations, ind	4		87.5	6.3	6.3				2.9	0.5	0.5			3.9
Presentations, grp	4		12.5	0.5	52.1	22.9			0.6	1.0		10.0	5.0	16.6
Quizzes	11	32.1	37.4	2.4	24.1	3.0	0.9	1.3	1.8	0.1	0.5	0.2	0.1	4.0
Laboratory tests	1		12.5		54.2	12.5	20.8		1.9		8.1	1.9	3.1	15.0
Midterm exams	15	33.1	32.8	8.5	12.1	4.0	9.5	4.8	5.1	2.2	2.2	1.3	1.5	17.2
Final exams	8	22.9	29.7	6.5	9.1	15.5	16.3	5.7	7.1	2.4	1.8	3.0	4.5	24.5

	K	C	Ap	An	S	E		Total:	100.0
Mean %:	10.7	17.7	22.3	15.8	16.7	16.4			
							K	C	Ap	An	S	E
						Total % of final grade:	12.1	20.6	9.3	16.2	22.9	18.9

The examination of the types of academic challenges did lean toward the rewarding students more for completing academic challenges written at the higher cognitive levels and less for lower cognitive work, but not entirely. Academic challenges such as the individual and group written reports, the group presentations and the laboratory tests emphasized the higher cognitive levels and when combined were worth a total of 45.6% of students' final grades (7 %, 7%, 16.6% and 15% respectively). Quizzes and individual presentations tended to emphasize the lower cognitive levels and were worth a total of 7.9% of students' final grades (4% and 3.9% respectively).

However several types of academic challenges were counter to the ideal. As was noted previously, the midterm exams and final exams tended to emphasize the lower cognitive levels but

they were worth 41.7% of students' final grades (17.2% and 24.5% respectively). Activities and problem sets were worth a total of 4.9% (3.6% and 1.3% respectively) although they were written to emphasize the higher cognitive levels. This parallels Pickford and Newcomb's study (1989) which concluded that activities tended to challenge students cognitively, but were rewarded the least.

Discussion and Recommendations

The focus of this study was to examine the academic challenges provided to students, how students were being cognitively challenged and how students were being rewarded, not to compare one course to another; this study was not a judgment of the choices made by professors. Instead, the assessment process is intended to provide benchmark information which may assist professors in examining the cognitive level of their academic challenges, how they are written, and how they reward students. It provides an opportunity for professors to question whether or not their academic challenges are accomplishing what they are intending.

This study establishes a framework that educators can use to analyze their academic challenges and to assess whether or not they are challenging students at the cognitive levels to which they aspire. It is hoped that this framework will assist educators to improve their effectiveness at developing students' ability to think at higher cognitive levels.

The cognitive distributions varied by course and by type of academic challenge as they should, given the variety of courses examined. The observed variation provides examples of the range of possibilities for using academic challenges. Because of differences in the content and structure of the courses, comparisons between the courses should not be made except to provide examples of the different ways to structure academic challenges and the different types of academic challenges that can be provided.

The observed variation between courses and within the academic challenge categories has generated more questions than answers. Recommendations for additional research include exploring questions such as:

- Is there a specific combination of types of academic challenges that would be most effective for developing students' thinking ability within a particular course?
- What number of academic challenges should be provided in a given course for maximum effectiveness?
- Given the recognized importance of developing students' ability to think at the higher cognitive levels and given the hierarchical nature of Bloom's taxonomy, is there a "best" distribution of the six cognitive levels for writing academic challenges?
- Does rewarding students more for work completed at the higher cognitive levels encourage the development of their thinking ability?
- How do student variables (such as attitude, motivation, challenge acceptance) affect the development of students' thinking ability?

- What interventions can be used to improve how professors are writing academic challenges to increase the cognitive challenge to students?
- Can this cognitive analysis process be used as a tool for detailing professors' teaching activities and therefore be used in promotion and tenure reviews?

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